

CLAIMS

What is claimed is:

- 1    1.    A magnetic head, comprising:  
2            a sensor having a free layer, the free layer having a magnetic moment; and  
3            hard bias structures positioned towards opposite ends of the sensor, the hard bias  
4                   structures stabilizing the magnetic moment of the free layer, each hard  
5                   bias structure comprising;  
6                   an antiparallel (AP) pinned layer structure, the AP pinned layer structure  
7                           having a middle pinned layer aligned along a plane of the free  
8                           layer of the sensor, and outer pinned layers positioned on opposite  
9                           sides of the middle pinned layer; and  
10                   an antiferromagnetic layer positioned towards each of the AP pinned layer  
11                           structures, each antiferromagnetic layer stabilizing a magnetic  
12                           moment of the pinned layer closest thereto.
- 1    2.    A head as recited in claim 1, wherein a net magnetic moment of the AP pinned  
2            layer structure is about zero.
- 1    3.    A head as recited in claim 1, wherein a thickness of the middle pinned layer is at  
2            least as thick as the free layer of the sensor.

- 1     4.     A head as recited in claim 1, wherein a thickness of the middle pinned layer is at  
2           least twice as thick as the free layer of the sensor.
- 1     5.     A head as recited in claim 1, wherein the outer pinned layers are misaligned from  
2           the free layer.
- 1     6.     A head as recited in claim 1, wherein the pinned layers of the AP pinned layer  
2           structure each include at least Co, wherein the pinned layers are separated by a  
3           layer of Ru.
- 1     7.     A head as recited in claim 1, wherein the antiferromagnetic layers each include at  
2           least one of PtMn and IrMn.
- 1     8.     A magnetic head, comprising:  
2           a sensor having a free layer, the free layer having a magnetic moment; and  
3           hard bias structures positioned towards opposite ends of the sensor, the hard bias  
4           structures stabilizing the magnetic moment of the free layer, each hard  
5           bias structure comprising;  
6           an antiparallel (AP) pinned layer structure, the AP pinned layer structure  
7           having a first pinned layer aligned along a plane of the free layer of  
8           the sensor, and at least a second pinned layer for pinning a  
9           magnetic orientation of the first pinned layer; and

10                    an antiferromagnetic layer positioned towards each of the AP pinned layer  
11                    structures, each antiferromagnetic layer stabilizing a magnetic  
12                    moment of the pinned layer closest thereto.

1     9.     A head as recited in claim 1, wherein a net magnetic moment of the AP pinned  
2           layer structure is about zero.

1     10.    A head as recited in claim 1, wherein a thickness of the first pinned layer is at  
2           least as thick as the free layer of the sensor.

1     11.    A head as recited in claim 1, wherein a thickness of the first pinned layer is at  
2           least twice as thick as the free layer of the sensor.

1     12.    A head as recited in claim 1, wherein the at least second pinned layer is  
2           misaligned from the free layer.

1     13.    A magnetic head, comprising:  
2           a sensor having a free layer, the free layer having a magnetic moment; and  
3           hard bias structures positioned towards opposite ends of the sensor, the hard bias  
4           structures stabilizing the magnetic moment of the free layer, each hard  
5           bias structure comprising;  
6           an antiparallel (AP) pinned layer structure, the AP pinned layer structure  
7           having a first pinned layer aligned along a plane of the free layer of

8 the sensor, and at least a second pinned layer for pinning a  
9 magnetic orientation of the first pinned layer.

1 14. A head as recited in claim 13, wherein each AP pinned layer structure includes a  
2 middle pinned layer aligned along a plane of the free layer of the sensor, and outer  
3 pinned layers positioned on opposite sides of the middle pinned layer.

1 15. A head as recited in claim 13, wherein a net magnetic moment of the AP pinned  
2 layer structure is about zero.

1 16. A head as recited in claim 13, wherein a thickness of the first pinned layer is at  
2 least as thick as the free layer of the sensor.

1 17. A head as recited in claim 13, wherein a thickness of the first pinned layer is at  
2 least twice as thick as the free layer of the sensor.

1 18. A head as recited in claim 13, wherein the at least second pinned layer is  
2 misaligned from the free layer.

1 19. A magnetic storage system, comprising:  
2 magnetic media;  
3 at least one head for reading from and writing to the magnetic media, each head  
4 having:

5                   a reading portion having the structure recited in claim 1;  
6                   a write element coupled to the sensor;  
7                   a slider for supporting the head; and  
8                   a control unit coupled to the head for controlling operation of the head.

1    20.   A magnetic storage system, comprising:  
2           magnetic media;  
3           at least one head for reading from and writing to the magnetic media, each head  
4           having:  
5               a reading portion having the structure recited in claim 13;  
6               a write element coupled to the sensor;  
7               a slider for supporting the head; and  
8               a control unit coupled to the head for controlling operation of the head.